Automatic Estimation of Mixed Layer Height

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GCEP SURE 1999

Argonne National Laboratory

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# Affiliated Programs

+ http://home.doe.gov/index .htm

+ http://www.atmos.anl.gov/ GCEP

+ http://www.anl.gov

+ http://www.atmos.anl.gov/ ABLE

Abstract

Study of the Planetary Boundary Layer (PBL) is important for understanding the transport and diffusion of pollutants in the lower atmosphere. One feature of the PBL that is of particular importance is the height of the mixed layer (z_i). During the day, strong surface heating causes thermal turbulence. The combination of thermal and mechanical turbulence mixes particles and gasses nearly uniformly throughout the mixed layer. The mixed layer is capped by a temperature inversion at z_i; this inversion impedes the entrainment of air above z_i into air below. As the day proceeds, however, the inversion is weakened by turbulence and the height of the mixed layer increases, usually reaching a maximum in the afternoon.

It has been demonstrated that the height of the mixed layer can be determined using acoustic sounders (sodar), lidar, and radar. Lidar and radar receive energy backscattered from particles throughout the mixed layer while sodar is sensitive to small-scale fluctuations in temperature near z_i caused by turbulence.
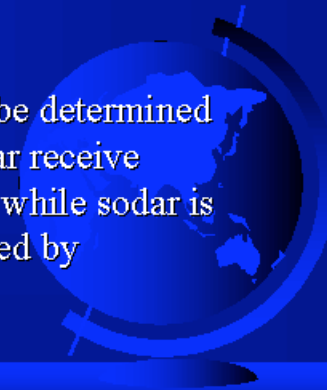
Abstract Continued

An automatic method for estimating the mixed layer height from a 915-MHz radar wind profiler (RWP) was developed at Argonne National Lab by R. L. Coulter and D. J. Holdridge. This type of RWP is sensitive to energy scattered off of moisture in the atmosphere. At the top of the mixed layer, strong gradients between moisture and temperature cause the signal strength to reach a relative maximum at z_i. Therefore, signal to noise ratio (SNR) plots were used to subjectively estimate z_i for each day from 1998 to July 1999 at the Whitewater and Beaumont ABLE sites. Each estimate was assigned a confidence level ranging from 1 (not a good estimate) to 5 (good estimate). During this project, actual SNR data for 1800 to 2000 UT each day (the afternoon hours) was averaged and compared to the corresponding estimate to determine if the rating system was accurate. In general, the objective averaged SNR data correlated with the estimated value of z_i.

Argonne Boundary Layer Experiment

The Argonne Boundary Layer Experiment (ABLE) facility was established in south-central Kansas within the Walnut River watershed in 1997. The purpose of ABLE is to foster the study of the dynamics and interactions within the planetary boundary layer. Within the site is an almost equilateral triangle of remote sensing sites (RSSes). This arrangement allows the estimation of the divergence of the horizontal wind field (D) and the vertical wind (w) from radar wind profiler (RWP) and minisodar (MS) data. The sites also include automatic weather stations (AWSs) and eddy correlation (EC) systems to estimate surface fluxes.

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ABLE Walnut River Watershed Remote Sensing Sites (RSS), KS

Site A: RSS Whitewater
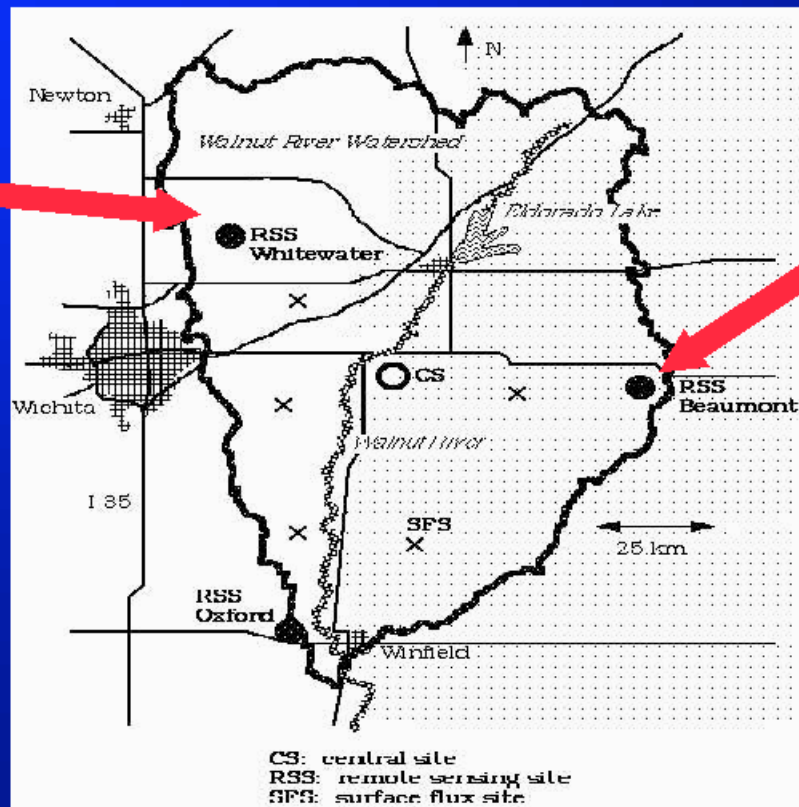
Site B: RSS Beaumont
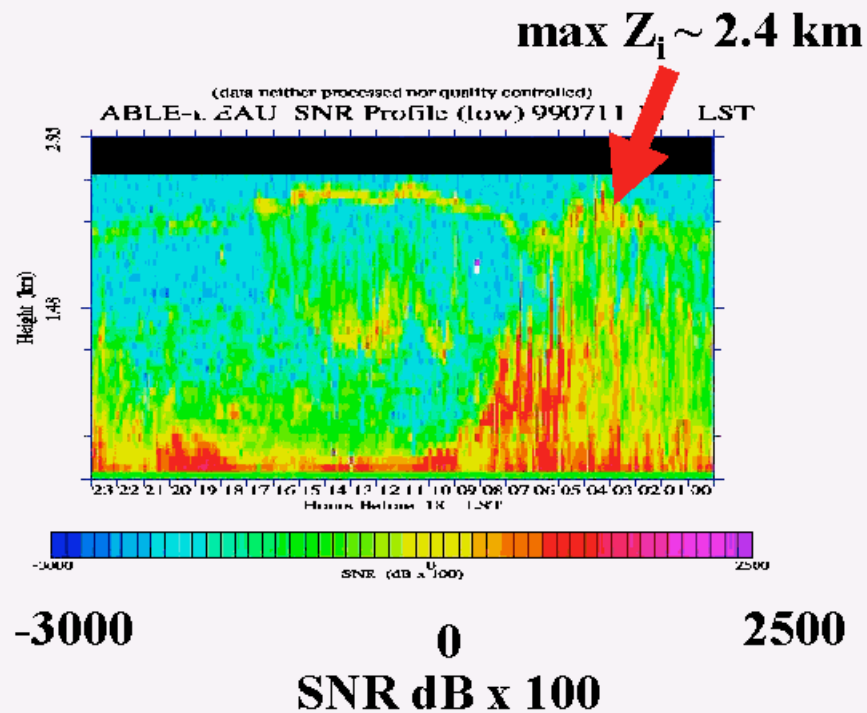
Site A: ABLE Remote Sensing Site #3

Whitewater, KS

Site B: ABLE Remote Sensing Site #5

Beaumont, KS

Example Signal to Noise Ratio (SNR) Profile

max $Z_i \sim 2.4$ km

(data neither processed nor quality controlled)
ABLE-... EAU SNR Profile (low) 990711 ... LST

-3000   0   2500

SNR dB x 100

- 915-MHz Radar Wind Profiler (RWP)

- Site B

- Low Power

- Z_i = Height of Mixed Layer

Sondes Good to Me
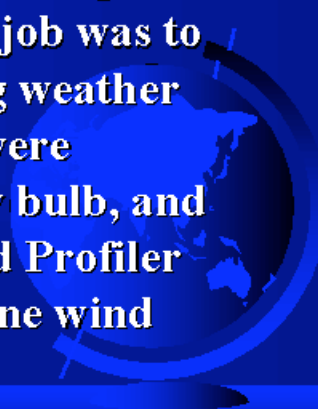

Cynthia Randles
with Angel

Buzzy the Radiosonde

Dr. Jeff Gaffney
with Angel

Introducing Angel the Cockatoo, the world's first weather balloon cartoon, and his trusty sidekick Buzzy the Radiosonde torpedo!!! Created by Dr. Jeff Gaffney.

NEOP Fieldwork

In addition to my SURE project, I was given the opportunity to do some fieldwork as part of the Atmospheric Chemistry Program's (ACP) Northeastern Ozone Particle study (NEOP). This was an air pollution study with the goal of investigating the urban polluted environment in and around Philadelphia, PA. Both local and distant sources were examined to discover the conditions leading to high ozone and increased particle concentrations. My job was to help provide meteorological support by launching weather balloons every two to three hours. Radiosondes were attached to each balloon to measure pressure, dry bulb, and wet bulb temperature. In addition, a Radar Wind Profiler (RWP) and minisodar (MS) were used to determine wind direction and speed.

Weather Instrumentation or Alien Colonization???
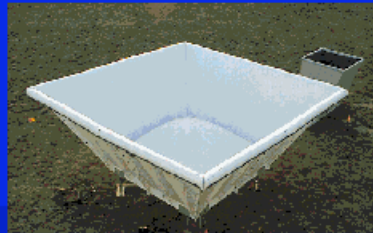
Top Left to Right:

• 915-MHz Radio Wind Profiler (RWP) and minisodar

• Cynthia and Tim at Area 51
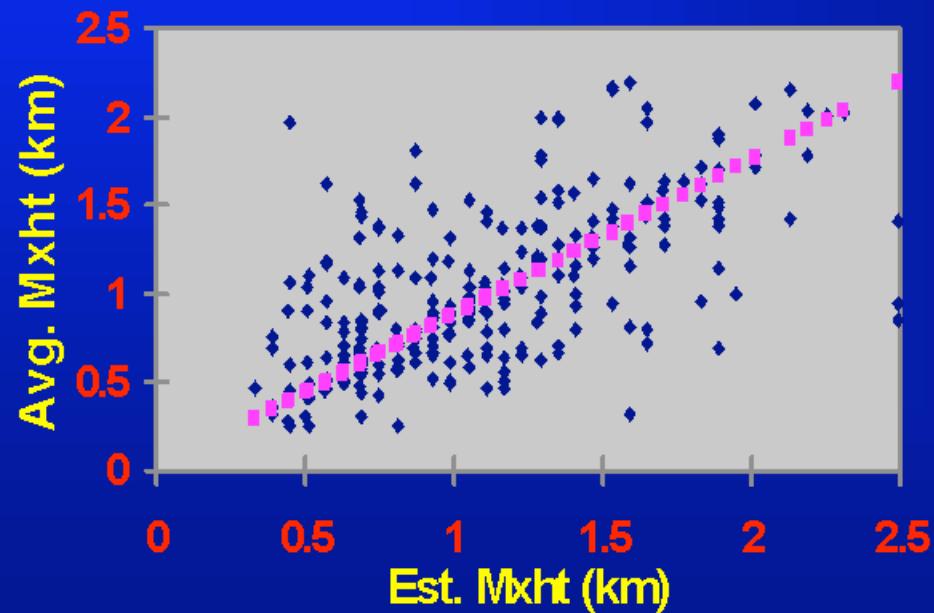
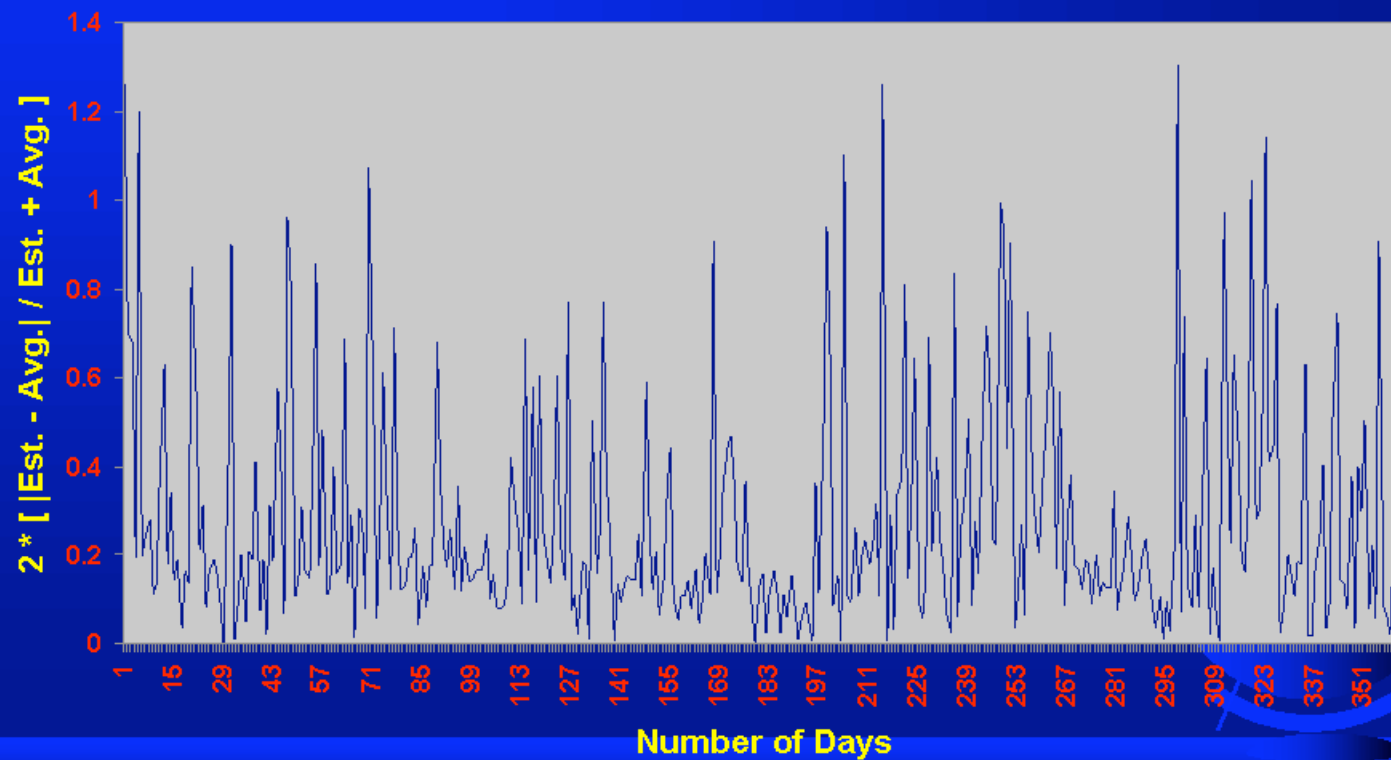• Weather Tower outside Philly

Bottom:

• Tether Sondes

Example Errors
Percent Error in Estimated and Average Height of
Mixed Layer: Site B

Acknowledgements/Contact Info

- **Richard Coulter**
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- **Jeff Gaffney**
  - gaffney@anl.gov
- **Cynthia Randles**
  - cynema@mit.edu

References

✦ **Coulter, R. L., 1979. A Comparison of Three Methods for Measuring Mixing-Layer.** *Journal of Applied Meteorology*, **18, 1495-1499 (1979)**

✦ **Coulter, R. L., 1997. Convergence Estimates Over the ABLE Region During CASES-97 Obtained from Radar Wind Profiler and Sodar Data. Argonne National Laboratory.**

✦ **Coulter, R. L. and Holdridge, D. J., 1998. A Procedure for the Automatic Estimation of Mixed Layer Height. Argonne National Laboratory.**